September 11, 2013

UVic Department of Electrical and Computer Engineering

COURSE OUTLINE
ELEC 571 – Underwater Acoustic Systems (CRN 11253)
(For updates see: http://www.ece.uvic.ca/~adam)

Instructor: Dr. A. Zielinski

Office Hours:
Days: Thursdays, or anytime, but make an appointment by email or phone
Time: 10:30 – 11:45 am
Location: EOW 411

Phone: 250 721-8622, fax 250 721 6052
E-mail: adam@uvic.ca
http://www.ece.uvic.ca/~adam/

Lectures
Section(s): A01
Days: Tuesdays and Thursdays
Time: 2:30 – 3:50 PM (Break: 3:20 – 3:25 PM)
Location: ECS 108

Important Dates (2013)

Classes Start Sept. 5, Thursday
Field Trip Oct. 8, Tuesday (no class, to be confirmed)
Thanksgiving Oct. 14, Monday
Project Proposals Oct 15, Tuesday
Midterm Test: Nov. 7, Thursday, 2:30 pm - 3:45 pm (to be confirmed)
Remembrance Day Nov 11, Monday
Reading Break: Nov 11-13, Monday-Wednesday
Guest Lecture Nov 14, Thursday
Project Presentations Nov 26, 28, Tuesday (Mr. Tom Dakin)
Last Class: Dec 3, Tuesday
Final Report due: Dec 20, Monday
UVic closed Dec 25 – Jan 1, 2014

Calendar Description
ELEC 571
Underwater Acoustic Systems
Units: 1.5

Course Objectives

The course will provide a condensed but comprehensive overview of applied underwater acoustics that will be of value to graduate and undergraduate students, researchers and engineers interested in exploiting sound transmission in the sea for scientific and technical purposes. Participants will learn the principles of underwater acoustics, acoustic transducers and important engineering parameters used in the design of diverse acoustic systems (sonar, depth sounder, navigation systems, seismic systems, etc). The topics to be covered will include characterization of underwater acoustic channels (propagation, ray tracing, reflection and refraction, ambient noise, reverberation), acoustic transducers and arrays (hydrophones and projectors, frequency response, directivity, beam-forming and steering) and sonar equations. Various applications (depth-sounder, side-looking sonar, underwater communications and navigation, and others) will be discussed and system performance evaluated using the system and channel's parameters. The course is suitable for students with a general engineering or physics background and can be taken for credit or audited. Can be also taken by fourth year ECE undergraduate students as a list 2 elective with the permission of the Department and the Dean of Graduate Studies (minimum required GPA from the last 15 units is 6.0). It also can be offered as an undergraduate course ELEC 496: Selected Topics in Electrical Engineering.

Course Outline

Unit 1. SOUND FUNDAMENTALS (30 pages)
- pressure waves
- sound speed
- pressure units
- sound reflection and refraction
- bottom reflection losses
- surface reflection losses

Unit 2. SOUND PROPAGATION (25 pages)
- source intensity
- spherical spreading
- sound absorption
- multiple reflections
- Lloyds mirror effect
- multiple reflections
- ray tracing

Unit 3. SIGNALS AND NOISE (19 pages)
- signal duration
- sonar resolution
- noise
- noise in ocean

Unit 4. SONAR PARAMETERS (18 pages)
- source level
- cavitation
- source directivity
- hydrophone response and directivity
- in-beam, in-band noise
- sonar targets

Unit 5. HYDROPHONES AND CONTINOUS ARRAYS (23 pages)
- electrical model for hydrophone
- hydrophone parameters
- preamplifier
- linear array
- directivity function and beam shading
- circular arrays
- rectangular arrays
- side-looking sonar
Unit 6. DISCRETE ARRAYS (13 pages)
- linear point array
- product theorem
- beam shading
- Dolph-Chebyshev beam-forming
- beam steering
- linear array with finite elements

Unit 7. REVERBERATION (16 pages)
- volume scattering
- surface back-scatter
- ocean surface
- bottom surface
- range calculation for side-looking sonars

Unit 8. ACOUSTIC TRANSDUCERS (21)
- hydrophone made of PVDF
- charge amplifier
- hydrophone made of PZT ceramic
- acoustic projectors
- equivalent circuit
- efficiency

Unit 9. APPLICATIONS (7 pages)
- multi-beam bathymetry
- navigation and positioning
- Doppler measurements
- communication

Requirements

Students are expected to attend all classes and to participate in the class discussions and submit assignments. The assignments should be handed in during class to the instructor on the prescribed date and also should be sent by email to adam@uvic.ca in the form of a Word or pdf file attachment. As part of the course requirements students are expected to complete a project on an approved topic of interest. It will involve an oral presentation of approx. 20 minutes duration (weight 10%) and the final written report of approximately 25-35 typed pages in length (weight 60%).

Required Text
Title: Class Notes for ELEC 571 – Underwater Acoustic Systems
Author: A. Zielinski © 2013
Publisher: University of Victoria, August 2013, 172 pages

Supplementary Texts
Title: An Introduction to Underwater Acoustics – Principles and Applications
Author: X. Lurton
(available in the Library Reserve Reading Room)

Title: Underwater Acoustic System Analysis
Author: W. S. Burdic
Publisher: Prentice--Hall, Inc., 1984, ISBN 0--13--936716--0, Call No. QC242.2, B87. (available in the Library Reserve Reading Room)
Assessment

Assignments 10%
Mid-term 20%
Project Presentation 10%
Final Project 60%

The final grade obtained from the above marking scheme will be based on the following percentage-to-grade point conversion (see UVic calendar):

<table>
<thead>
<tr>
<th>Passing Grades</th>
<th>Grade Point Value</th>
<th>Percentage for Instructor Use Only</th>
</tr>
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<tr>
<td>A+</td>
<td>9</td>
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<tr>
<td>A</td>
<td>8</td>
<td>85 – 89</td>
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<tr>
<td>A-</td>
<td>7</td>
<td>80 – 84</td>
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<tr>
<td>B+</td>
<td>6</td>
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<tr>
<td>B</td>
<td>5</td>
<td>73 – 76</td>
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<tr>
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<td>4</td>
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<tr>
<td>C+</td>
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<table>
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<th>Description</th>
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<tr>
<td>E</td>
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<td>35 - 49</td>
<td>Fail, conditional supplemental exam. (For undergraduate courses only)</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>0 – 49</td>
<td>Fail, no supplemental.</td>
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<tr>
<td>N</td>
<td>0</td>
<td>0 – 49</td>
<td>Did not write examination, Lab or otherwise complete course requirements by the end of term or session; no supplemental exam.</td>
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Deferred exams will normally be written at the start of the student's next academic term; i.e., approximately 4 months following the deferral of the exam.

Accommodation of Religious Observance
See [http://web.uvic.ca/calendar2013/GI/GUPo.html](http://web.uvic.ca/calendar2013/GI/GUPo.html)

Policy on Inclusivity and Diversity
See [http://web.uvic.ca/calendar2013/GI/GUPo.html](http://web.uvic.ca/calendar2013/GI/GUPo.html)

Standards of Professional Behaviour
You are advised to read the Faculty of Engineering document Standards for Professional Behaviour at [http://www.engr.uvic.ca/policy/professional-behaviour.php](http://www.engr.uvic.ca/policy/professional-behaviour.php) which contains important information regarding conduct in courses, labs, and in the general use of facilities. Cheating, plagiarism and other forms of academic fraud are taken very seriously by both the University and the Department. You should consult [http://web.uvic.ca/calendar2013/FACS/UnIn/UARE/PoAcI.html](http://web.uvic.ca/calendar2013/FACS/UnIn/UARE/PoAcI.html) for the UVic policy on academic integrity.